DOCUMENT RESUME

ED 039 017 PS 002 862

AUTHOR	Ricciuti, Henry N.
TITLE	Malnutrition, Learning and Intellectual Development: Research and Remediation.
INSTITUTION	Cornell Univ., Ithaca, N.Y. Cornell Research Program in Early Childhood Education.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C. Div. of Educational Labs.
PUB DATE	2 Sep 69
CONTRACT	OEC-3-7-070706-3118
NOTE	33p.; Paper presented at the annual meetings of the American Psychological Association, Washington, D.C., September 2, 1969
EDRS PRICE	EDRS Price MF-$0.25 HC-$1.75
DESCRIPTORS	Biological Influences, Child Development, *Cognitive Development, Early Childhood, Environmental Influences, *Health, *Nutrition, Research Needs, *Research Reviews (Publications)
IDENTIFIERS	*Malnutrition

ABSTRACT

After a discussion of the problem of malnutrition and its effect on intellectual development, this paper concentrates on the study of protein-calorie malnutrition in infants and children as it occurs in postnatal and subsequent development. An overview and summary of the principal investigations on the relationship of malnutrition to intellectual development is presented. Some studies focus on infants and children whose malnutrition required hospitalization and others consider nonhospitalized children suffering from malnutrition. The difficulties of defining and assessing protein-calorie malnutrition and separating its influence from other biological, social, and environmental conditions are emphasized. Examples of studies involving attempts to improve children's nutritional status by means of dietary intervention are also given. A discussion follows of the substantive and practical implications of the research studies. It is concluded that psychologists must continue to develop educational programs that facilitate the physical and psychological development of children both at home and in school. (DR)

U. S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

ED039017

MALNUTRITION, LEARNING AND INTELLECTUAL DEVELOPMENT: RESEARCH AND REMEDIATION[1]

Henry N. Ricciuti[2]

Cornell University

The devastating effects of severe malnutrition and disease in various regions of the world where conditions of extreme poverty prevail have been recognized for a long time. A variety of programs for alleviating these effects have been carried on particularly since the end of World War II, by public and private agencies in this country and others, as well as through the United Nations. It is only during the past several years, however, that the issue of malnutrition and its implications for human development and human welfare in the United States has become a matter of considerable and rather widespread public concern. The aroused public interest in the problem of malnutrition in this country may be viewed as a natural part of our society's increasing commitment, during the past ten years or so, to wide-scale programs for improving the economic, educational and health conditions of the poor, that is, our "war on poverty". At the same time

---

1. Presented as invited address, Division of School Psychologists, American Psychological Association Annual Meetings, Washington, D. C. September 2, 1969. Preparation of paper supported in part by Cornell Research Program in Early Childhood Education, a component of the National Laboratory in Early Childhood Education (U. S. Office of Education Contract No. OEC-3-7-070706-3118). Points of view or opinions stated do not necessarily represent official Office of Education position or policy.
Paper to be published in Psychology and the Problems of Society. Washington, D. C.: American Psychological Association. 1969 or 1970.

2. Department of Human Development and Family Studies, College of Human Ecology, Cornell University, Ithaca, New York 14850.

PS 002862

it seems to me, the increasing concern with malnutrition as a public health problem of particularly compelling priority, is based in part on the growing conviction that malnutrition may adversely affect learning and intellectual development in children, perhaps to the degree of producing serious and irreversible mental retardation in some instances.

There has been ample research evidence for some time now that children's physical and biological development may be seriously and even permanently impaired by the combination of malnutrition, infection and parasitic disease which is endemic in various poor populations (Graham & Morales, 1963; Pre-school Child Malnutrition, 1966, Pp. 3 - 73; Scrimshaw & Gordon, 1968, Pp. 16-90). However, it is only during the past dozen years or so that concerted research efforts have been directed at the question of the influence of malnutrition on mental development and learning in children (Latham, 1969; Scrimshaw, 1967). What I should like to do in this paper is to examine the status of our present knowledge on this rather complicated problem, and to explore some aspects of recent research which might be of particular relevance to you in your work as school psychologists. At the same time, I want to consider some of the implications of our current knowledge about malnutrition and mental development with regard to public programs concerned with the alleviation of malnutrition, and with the facilitation of intellectual development in children.

MALNUTRITION IN AMERICA: A CURRENT NATIONAL CONCERN

Let me begin by briefly outlining some of the major features of our present National concern with the problem of malnutrition. You are familiar, I'm sure, with two recent reports which effectively drew public attention to the existence of allegedly widespread and severe malnutrition

in certain parts of the United States. One of these was the "Hunger U.S.A." report, from the Citizens' Board of Inquiry into Hunger and Malnutrition in the United States (1968); the other was the CBS television program entitled "Hunger in America" which followed shortly thereafter in the late Spring of 1968 (Kuralt, 1968). These reports were both applauded for drawing public attention to a seriously overlooked problem confronting our poor, and criticized for presenting an inaccurate view of the problem.

At the present time, fortunately, with the support of Congress, the Department of Health, Education and Welfare, and professional organizations in Nutrition and in Pediatrics, major efforts are well underway to assess more precisely the nature and scope of malnutrition in this country, by means of systematic survey and examination techniques. One of these efforts is the Preschool Nutrition Survey, initiated under sponsorship of the Children's Bureau beginning in late 1966 (Cohen, 1968; Lowe, 1967). This study, which is still going on, is expected to provide detailed information concerning the growth and nutritional status of a large sample of children ages one to six, drawn from many regions of the United States. The other major effort is the National Nutrition Survey, also under H.E.W. support, which will provide information on the nutritional status of a large sample of individuals of all ages, totalling 70 - 75,000 people, or 18,000 families, approximately, with particular emphasis on people living in economically deprived areas (Cohen, 1968; Schaefer, 1969). Thus, there will soon be forthcoming a great deal of hitherto unavailable factual information about the nature and scope of malnutrition at all age levels in various segments of the United States population.

In the meanwhile, a variety of programs to improve the nutritional

status of children, pregnant women and other adults who are particularly likely to be at risk are being continued and expanded (Egan, 1969). These include feeding programs for children in Head Start and other school settings; the Supplementary Food Program for needy infants, preschool children, pregnant and post-partum women; nutrition and health programs incorporated in the recently established Parent and Child Centers and the Maternity and Infant Care projects; and a variety of other nutrition education programs. On the research front, for the past half-dozen years or so private as well as public agencies such as the National Institute of Child Health and Human Development, for example, have been exerting a good deal of leadership in stimulating and supporting a broad range of basic and applied research on malnutrition and development, with considerable emphasis on the particular problem of intellectual development and learning in children (National Institute of Child Health and Human Development Conference Reports, 1969a, b). Thus, in the past few years, there has been a substantial increase in the number of investigators from different disciplines in this country, who have begun to direct their research efforts toward this problem (Scrimshaw & Gordon, 1968).

It is obvious that regardless of the present status of our research evidence concerning the influence of malnutrition on learning and intellectual development in children, effective programs for combating malnutrition wherever it is found must continue to be developed and expanded. It has been pointed out and demonstrated over and over again that where malnutrition exists as a serious health problem in disadvantaged populations, it is not an isolated phenomenon but part of a complex of interlocking social and biological conditions which take a heavy toll indeed in terms of human welfare (Collis & Janes, 1968; Scrimshaw, 1964). Severe

educational and economic handicap, infection, parasitic disease, malnutrition, complications of pregnancy and childbirth--all these conditions, which tend to be self-perpetuating, manifest their consequences in such problems as high rates of prematurity and infant mortality, impaired physical growth, and, as you are well aware, impaired intellectual development and school learning (Birch, 1968; Knobloch & Pasamanick, 1966; Pasamanick & Knobloch, 1966). Clearly we need to remain committed to the development of programs which are aimed at eliminating this entire pattern of socially and physically debilitating conditions.

THE PROBLEM OF MALNUTRITION AND MENTAL DEVELOPMENT

While necessary programs for combating malnutrition and the other conditions mentioned are continued and expanded, research efforts must continue to be directed toward the central question: what is the influence of malnutrition on intellectual development, learning and educational achievement in children; can this influence be separated from the concomitant effects of the other social, environmental, and biological conditions typically associated with malnutrition? More specifically, how do the effects of malnutrition vary as a function of age of onset, severity, duration, and the particular type of malnutrition involved? How severe are the effects on intellectual development? Are they reversible with nutritional rehabilitation; must remediation occur at a particular point in development in order to be effective? Can the effects be assessed in terms of specific psychological functions and behavioral outcomes, not simply in terms of general intelligence measures? How are the effects on intellectual performance mediated--through altered brain function, impaired

PS 002862

learning capacity, reduced responsiveness to the environment or through some other process?

These are important and difficult questions, of a sort familiar to most developmental and child psychologists. By their very nature, they are particularly difficult to answer in research with human subjects, Moreover, some investigators feel that definitive answers to many of these questions can be obtained only from the kinds of controlled experimentation that are possible in animal studies. As a matter of fact, an increasing amount of animal research related to these issues has been underway during the past few years, with the results being of considerable heuristic value insofar as malnutrition in children is concerned (Barnes, 1969; Harlow & Harlow, 1969; Scrimshaw & Gordon, 1968, pp. 167-250).

It should be clear that the research questions just posed concerning the influence of malnutrition on intellectual development, are not only of theoretical importance to developmental psychologists and biologists, but they are also of very great practical significance, since answers to them should help us make wiser decisions and plans concerning specific programs aimed at facilitating the intellectual and educational development, as well as the physical development of young children.

MALNUTRITION: SOME PROBLEMS OF DEFINITION AND ASSESSMENT

Before going on to a review of the research on malnutrition and mental development in children, let me spend a few minutes on some brief but necessary definitions and distinctions. First, what about the term "malnutrition" itself? A recent definition reflects current usage of the term as a rather broad concept, referring to "an impairment of health and

physiological function resulting from the failure of an individual to obtain all the essential nutrients in proper amount and balance" (Schaefer, 1969). According to this usage, as a generic term malnutrition would include:

Undernutrition--representing a condition of impaired health due to the consumption of an insufficient quantity of food over an extended period of time;

Specific deficiencies--due to the lack of particular essential nutrients, such as vitamins, iron, etc.; and

Overnutrition--impaired health due to the consumption of an excessive quantity of food, or of one or more nutrients, over an extended period of time (e.g., obesity).

My major concern in this paper will be with the first condition just mentioned, namely malnutrition (or undernutrition), produced essentially by an insufficiency of protein and calories in the child's diet, commonly referred to as "protein-calorie malnutrition", which is regarded by many as the most serious nutritional problem on a world wide basis (Jelliffe, 1959). I shall also examine briefly, however, some research on mental development and specific nutritional deficiencies.

Protein-calorie malnutrition includes the conditions of nutritional marasmus, involving a severe inadequacy of intake of all nutrients, usually from the earliest months of life, producing infants whose physical development is grossly impaired; and kwashiorkor, which is primarily an insufficiency of protein occurring in children typically toward the end of the first year or in the second year of life, usually after the birth of a younger sibling (Graham & Morales, 1963; Scrimshaw, 1963).

Nutritional marasmus is usually a rather long term condition beginning very early in life, while kawshiorkor often takes the form of a rather acute illness, occurring somewhat later on. Many combinations and mixtures of these conditions are found in practice, varying greatly in severity and duration. I should mention, incidentally, that when the nutritionist refers to marasmus in infants, he is not using the term as most psychologists have come to know it through the influence of Spitz particularly (1945), implying a condition produced primarily by psychological deprivation.

One of the difficulties confronting researchers concerned both with nutritional surveys and with the relationships between malnutrition and intellectual development, is the fact that it is not at all easy to secure reliable and valid assessments of nutritional status in children. This is particularly true if one is concerned with measurement throughout a broad range of nutritional variation, and not just with the identification of clinically obvious and severe malnutrition (Jelliffe & Jelliffe, 1968). In the current National Nutrition Surveys which were mentioned earlier, nutritional status is being assessed through three types of measures: 1) evaluation of food intake from detailed dietary reports; 2) physical or clinical evaluations, including various anthropometric and radiographic measures; and 3) biochemical evaluations of various specific nutrients from blood and urine samples.

The interpretation of such measurements as indicators of nutritional status is considered rather difficult, and many nutritionists feel that such measurements are most valid when used in combination with one another. Moreover, published standards for judging adequacy of nutritional status

from a particular index vary considerably, resulting in variable estimates of the frequency of various specific nutritional deficiencies. It is for reasons such as these, that the data collected in the National Nutrition Survey are to be reviewed and interpreted by panels of experts from several national scientific and medical groups.

I might mention parenthetically at this point, that I do not believe I need dwell at length on the very similar and familiar problems which face us as psychologists, when we try to obtain valid and reliable measurements of relevant perceptual-cognitive, learning, and motivational functions in young children from infancy through the elementary school years! We might take some slight comfort from the fact that our nutritionist and pediatric colleagues have just as many problems in the assessment of nutritional status in children!

A further definitional note concerns the necessity of distinguishing between hunger and malnutrition, two terms which have tended to be blurred and used interchangeably in recent days. A child who frequently comes to school without breakfast, or who misses lunch often, may be hungry, but he may or may not be significantly malnourished. While it is conceivable that his school performance might be affected adversely by inattentiveness and distractability associated with hunger, we clearly need to differentiate these potential influences on school learning, about which we know very little, from those which might be the result of long term protein-calorie malnutrition, perhaps in the form of altered central nervous system functions, reduced responsiveness to the learning environment, etc. Children sufficiently malnourished to undergo changes of this sort do not necessarily experience extended periods of "hunger",

as commonly defined. In fact, many severely and acutely malnourished children tend to be characterized by apathy, withdrawal, and loss of appetite, rather than by the increased activity and restlessness associated with hunger (Cravioto, Delicardie, & Birch, 1966; Trowell, Davies, & Dean, 1954).

Now a final definitional comment. Because of time constraints, my discussion today will deal primarily with protein-calorie malnutrition which occurs during postnatal and subsequent development in children. I must therefore omit consideration of the adverse influences on children's psychological development and educational achievement brought about by complications of pregnancy and childbirth, including prematurity, which are due in part at least, to maternal malnutrition and ill health (Birch, 1968; Drillien, 1964). At the same time, I shall have to omit consideration of a number of problems which involve particularly complicated interactions of nutritional, psychological, and social difficulties in children, some of which you may deal with clinically as school psychologists. I refer here to such problems as the abused or neglected child who is also malnourished (Helfer & Kempe, 1968), the so called "failure to thrive" babies sometimes found in socially advantaged and apparently benevolent homes (Leonard, Rhymes, & Solnit, 1966), "anorexia nervosa" or extreme loss of appetite (Kay & Leigh, 1954), and obesity or caloric overnutrition (Mayer, 1968), which some feel is one of our major nutritional problems in this country, rather than protein-calorie malnutrition.

RECENT RESEARCH ON MALNUTRITION AND MENTAL DEVELOPMENT

a. Preliminary summary of general conclusions

After these rather lengthy introductory comments, we're now ready to turn to the central question of the influence of protein-calorie malnutrition on learning and intellectual development in children. What conclusions can be drawn at this point from the research evidence based on humans? Let me start out immediately with the briefest kind of summary statement, with which I believe a good many of my nutritionist, pediatrician, and psychologist colleagues would concur.

First, there is reasonably good evidence that protein-calorie malnutrition occurring in the first year of life, which is severe enough to markedly impair physical growth and to require hospitalization and treatment, may have adverse effects on the child's mental development, perhaps even to the extent of producing in some instances borderline or more severe mental retardation which does not appear to be readily remediable under conditions of nutritional rehabilitation. Severe malnutrition beginning in the second year of life or later, often taking the form of kwashiorkor, appears to produce adverse effects on mental development which are not as severe and seem to be more amenable to treatment. In both instances, however, it is not entirely clear whether the condition of postnatal malnutrition is the sole or even principal determinant of impaired intellectual functioning, nor do we fully understand how its influences are mediated.

Secondly, when we consider the chronic, moderate-to-mild protein-calorie malnutrition which appears to be endemic in many economically disadvantaged populations, then the evidence as to effects on intellectual

and learning functions attributable to malnutriton as such, independently of the concomitant influences of social and environmental factors, is very weak and unclear indeed, and we need considerable further research on this question before it can be satisfactorily answered. I think it's reasonable to assume, however, in the light of our present knowledge of child development, that the effects of moderate or mild malnutrition on intellectual development and school learning are probably minimal, in comparison with the influences attributable to other major environmental, experiential, and genetic determinants of mental development.

b. Studies of children hospitalized for malnutrition

Now let me briefly describe some of the major studies which have been done and summarize their findings in somewhat more detail. The great majority of investigations of protein-calorie malnutrition and intellectual development have been carried out in economically disadvantaged populations in Latin America, Africa and Asia. Let's consider first some studies which have been concerned with the effect of malnutrition severe enough to require hospitalization and treatment in the first two to three years of life. Several of these studies have evaluated malnourished infants during their hospitalization and rehabilitation or shortly thereafter, while others have been concerned with effects observable later in the preschool or school age period.

One of the earliest and frequently quoted studies was done in Mexico City in the early 1960's by Cravioto, who has been one of the foremost investigators in this field, and Robles (1965). Twenty infants hospitalized for severe protein-calorie malnutrition were examined with the Gesell infant scale every two weeks during treatment and rehabilitation,

which lasted as long as six months for some infants. All infants were well below age norms on the Gesell when admitted (D.Q.'s mainly below 60). During rehabilitation, fourteen children who had been admitted for treatment between 15 and 42 months of age came progressively closer to age expectations on the Gesell. However, the six infants whose malnutrition led to hospitalization before the age of six months did not show any recovery of their developmental deficit during nutritional rehabilitation.

A study conducted in Venezuela at about the same time dealt with sixty children hospitalized at some time between 15 and 71 months of age for severe malnutrition, primarily of the kwashiorkor type (Barrera-Moncada, 1963). When examined after seven to twelve weeks of treatment, these children had a mean Developmental Quotient of 65 on the Gesell scale. Some of these children were reexamined two years later and achieved IQ's approaching the normal range.

Several years ago Brockman and Ricciuti (1969) did a study with twenty children from 12 to 43 months of age who had been hospitalized for severe nutritional marasmus in Lima, Peru sometime between 2 1/2 and 42 months of age. We attempted to assess cognitive functioning involved in primitive categorizing behavior in these infants, by means of some simple sorting techniques which we had previously used with normal infants. The test performance of the malnourished infants was substantially and significantly below that of a control group of children from the Lima slums, who had been selected on the basis of their being taller than the malnourished children, and hence, presumably without a previous history of severe malnutrition[3].

---

3. The use of stature as an index of nutritional background poses substantial interpretive problems (Pollitt & Ricciuti, 1969), as will be discussed later in this paper.

While there are many obvious technical difficulties in interpreting the results of studies like those I've just summarized, they indicate, as do a number of other studies in the literature (Geber & Dean, 1956; Pollitt & Granoff, 1967), that infants tested during and shortly after rehabilitation from severe protein-calorie malnutrition requiring hospitalization in the first several years of life, show substantially reduced performance on developmental and cognitive tests. Moreover, some of the studies, at least, suggest that severe malnutrition which occurs in the second year of life or later may have relatively less severe and long lasting effects on psychological development than seems to be the case for malnutrition occurring in the first year.

Now let's consider investigations in which the influence of severe malnutrition requiring hospitalization early in life is examined in regard to the intellectual status of the children somewhat later on in childhood. Two studies suggest that children hospitalized for malnutrition in the first year show appreciably reduced intellectual functioning when subsequently examined at about four years of age (Chase & Martin, 1969; Monckeberg, 1968). As far as I know, the Chase and Martin study is the only investigation of protein-calorie malnutrition and intellectual development carried out on a sample of children in the United States. Working in Colorado, these investigators have recently found that twenty children who had been hospitalized for malnutrition before the age of one year had a mean Developmental Quotient of 82 when examined approximately three and a half years later. This performance, based on the Yale Revised Developmental Examination, was significantly lower than the mean Developmental Quotient of 99 achieved by a carefully matched control group of non-malnourished children.

When they contrasted the malnourished infants hospitalized before and after four months of age, those who had been admitted after the age of four months, and who presumably had been malnourished for a longer period of time without treatment, had a mean Developmental Quotient of 70. On the other hand, children who were admitted and treated prior to four months of age had virtually normal Developmental Quotients when examined three and a half years later, and were also less retarded in physical growth at that time than the later treated infants. (It should be mentioned that these infants were probably not as severely malnourished as those included in some of the previously mentioned studies from Latin America.) While the Chase and Martin study involved considerably more careful matching of the malnourished and control subjects on social and environmental factors than has ordinarily been the case, the authors themselves point out that from a research point of view "it appears impossible to completely separate undernutrition from associated environmental influences, as they are part of the same entity".

What about the intellectual functioning of school-age children known to have been hospitalized for malnutrition during the first two or three years of life? A number of studies provide suggestive evidence, at least, that these children may perform less well than children without a history of early and severe malnutrition. One of the most recent of these investigations was carried out by Cravioto and his colleagues in Mexico City (Cravioto, Pinero, Arroyo, & Alcade, 1969). They tested thirty-nine children from 5 to 10 years of age, all of whom had been hospitalized at some time between 4 and 30 months of age for severe malnutrition, primarily of the kwashiorkor type. As control subjects

they employed the nearest-age siblings of the experimental children. The previously malnourished children were found to have substantially lower WISC IQ scores, with nearly fifty percent of them scoring below 70, in contrast with nearly thirty percent of the control subjects. Furthermore, the malnourished children made more errors on a form recognition task and on a test of auditory-visual integration previously employed by Birch in his research in this country with retarded readers (Birch & Belmont, 1964).

In this report Cravioto and his collaborators caution against interpreting their results as evidence of a direct "causal relationship between malnutrition and mental competence" even with the use of siblings as controls. Nevertheless, they regard their results as suggesting that for children growing up in an environment generally capable of impeding intellectual growth, the added presence of an episode of severe malnutrition early in life increases the likelihood that there will be an impairment of the development of intellectual and learning functions important for the child to profit from the school experience.

A similar study was conducted very recently in India (Champakam, Srikantia, & Gopalan, 1968). Nineteen children hospitalized for kwashiorkor sometime between 1 1/2 and 3 years of age were examined when they were between 8 and 11 years of age on several tests of intersensory integration, and on a number of tests of memory, perceptual, abstract and verbal ability. In comparison with the performance of control children matched for various social background factors, the previously malnourished children performed substantially less well, particularly in the 8 to 9 year group. Once again, with regard to problems of interpretation, these authors point out that the same environmental factors which might contribute to the development of kwashiorkor in some children and not in others in the same environ-

ment, might well contribute directly to the reduced intellectual performance which was observed.

c. Studies of non-hospitalized children

Thus far we've been considering studies in which the malnutrition under investigation was clearly severe enough to warrant hospitalization during the first two to three years of life. A number of studies have dealt with children whose restricted physical growth, particularly in stature, is taken as suggesting a history of less severe but chronic malnutrition. In many respects, the results of these investigations are particularly difficult to interpret because of the problems imvolved in using extreme differences in physical stature, such as height, weight or head circumference, as the principal indices of nutritional status. It is well known, for example, that while differences in height may reflect nutritional factors, they may also reflect a variety of other biological and social characteristics of the environment, or of the individual, which are capable of influencing intellectual development (Douglas & Blomfield, 1962; Pollitt & Ricciuti, 1969).

In a frequently quoted study by Stoch and Smythe in South Africa (1968), twenty children were selected for study when they were between 10 months and 3 years of age, on the basis of markedly reduced height, weight and head circumference. Their physical and intellectual development were checked periodically over approximately eleven years. During this follow-up period these children scored consistently and substantially lower than a control group, by fifteen to twenty IQ points, on tests such as the Gesell, Merrill-Palmer, and most recently, the New South Africa Individual Intelligence Scale. Educational placement of these children also was

reported as lagging considerably behind average for age. While the consistency of these findings over an eleven year period is impressive, it is important to emphasize, as a number of people have already pointed out (e.g., Scrimshaw, 1967), that it is impossible to determine in this study to what extent malnutrition might account for the observed test score differences. The control children, although selected from the same socio-economic class as the malnourished youngsters, came from more stable homes with markedly better living conditions, and they were attending an all day nursery school when the study began.

Similar problems of interpretation arise in connection with two recent studies by Cravioto and his colleagues in which tall and short school-age children were selected for study on the assumption that the likelihood of their having been previously exposed to nutritional risk was markedly different. Instead of relying on the usual measures of general intelligence, these investigators evaluated children's ability to integrate information from different sense modalities using procedures previously developed by Birch and Lefford (1964). In a Guatemalan village study of children from 6 to 11 years of age, the tall children tended to make fewer errors than short children in identifying geometric forms on the basis of visual, haptic or tactual, and kinaesthic information, particularly in the younger age groups (Cravioto, Delicardie, & Birch, 1966). While the tall and short children did not differ significantly on a number of social-environmental background factors assessed as controls in the research, maternal education was markedly higher in the case of the tall children, illustrating again the difficulty of separating presumed nutritional differences in tall and short children, from the influence of

associated social factors such as parental education. A later study of auditory-visual integration in several hundred rural Mexican school children from 7 to 12 years of age again revealed slight differences in favor of tall children, particularly at age twelve (Cravioto, Gaona, & Birch, 1967). No information is available in this latter report concerning possible social or environmental differences in the contrasting stature groups.

A number of recent investigations of malnutrition and intellectual development, such as the ones just mentioned, have begun to assess rather specific perceptual-cognitive functions in preschool or school age malnourished children. In some very interesting recent work in Guatemala, Klein (1969) gave several tests of short term memory and simple incidental learning to 20 children five and a half years old, who had previously been sufficiently malnourished to be treated at a rehabilitation clinic (but not hospitalized). These children performed significantly poorer on the tasks mentioned than a taller control group with generally similar social background, including the presence of malnutrition in the home, in a sibling. In a rather rare replication study employing the same tests, these performance differences were not found by Klein, although significant differences were obtained in favor of control children on two new tasks involving memory and learning under conditions requiring rapid information processing. Klein has suggested that this failure to replicate the earlier findings might have been due to the presence of less severe malnutrition in his second study, or to the fact that the examiners in the second study were unaware of the differences in the nutritional histories of the experimental and control subjects.

At this point in my review, I hope I've given you some feeling both for the major suggestive findings coming from the research literature, as well as the uncertainties and ambiguities we're confronted with when we try to evaluate the effect of protein-calorie malnutrition on intellectual development in children, as an influence separate from the other biological, social and environmental conditions usually associated with it.

d. Studies involving nutritional remediation and biochemical assessments

I would like to turn next to some brief examples of studies in which investigators have looked for changes in intellectual development as a possible consequence of rather extensive attempts to improve children's nutritional status by means of dietary interventions of various kinds. Interestingly enough, while there are some elaborate studies of this kind currently underway or in the planning stage in Latin America (Canosa, 1968; Latham, 1969; Velez, Vasco, Echeverri, & Vitale, 1969), this was a problem that nutritionists, home economists and early childhood educators addressed themselves to in the United States as long ago as the early 1920's when, as a part of the early child development movement, there was much emphasis placed on the school's role in improving the general health and nutritional status of children (Bliss, 1921; Smith & Field, 1926).

In more recent times, Kugelmass, Poull, & Samuels (1944) carried out a study in New York City in which fifty children 2 to 9 years of age who were judged to be nutritionally deficient but in the normal IQ range, were reported to have gained eighteen IQ points, on the average, after two to three years of an unspecified nutritional improvement program. Since there is virtually no way of determining whether the IQ change was in fact due

to the presumed nutritional changes or to other social and environmental variables, this study, while often quoted, has apparently not been taken too seriously for the most part.

Several years later, in a much more carefully controlled study, Harrel (1946) reported that orphanage children in Virginia who were given thiamine (vitamin B-1) daily over a one year period, scored significantly higher than a carefully matched placebo control group of orphanage children on a number of tests of perceptual and intellectual functions important in school learning. It has recently been suggested that this improvement, which was not confirmed in a subsequent Canadian study (Robertson, Tatham, Walker, & Weaver, 1947), might have been achieved because the orphanage children were originally deficient in thiamine. Sandstead, Carter, and House (1969), who proposed the interpretation just mentioned, have recently completed a preliminary study of nutritional deficiencies in disadvantaged preschool children enrolled in a compensatory language program in Nashville, Tennessee. They found that children with biochemical evidence of a deficiency in thiamine (or vitamin B-1) tended to have lower initial Stanford-Binet IQs ($r = .45$). IQ was unrelated however, to other nutritional indices such as amount of iron, hemoglobin, and vitamin A.

Beller (1969) has also found no relationship between general intelligence and measures of iron deficiency anemia in disadvantaged preschool children in Philadelphia. However, he reports preliminary evidence suggesting that anemic children show more aimless manipulation, less purposeful activity, and a much lower attention span on several tasks than do non-anemic children.

The last few studies mentioned, which clearly are not conclusive as yet, are nevertheless illustrative of the currently increasing research

interest in relating specific nutritional deficiencies, often biochemically determined, to specific perceptual, cognitive, and attentional processes, as well as to general intellectual functioning. (See also Coursin, 1967.)

RESEARCH IMPLICATIONS: SUBSTANTIVE AND PRACTICAL

Having completed this brief overview and summary of some of the principal investigations of malnutrition and intellectual development in children, let us examine some of the main implications of these studies, first from the point of view of what we've learned in regard to some of the specific research questions I posed earlier, and then from the point of view of programs for facilitating physical, psychological, and educational development in young children, particularly in this country.

Does malnutrition adversely influence learning and intellectual development in children? If so, how severe are these effects, and are they enduring or remediable?

On the basis of the kinds of studies already summarized, and by inference from related research concerned with brain growth in severe malnutrition in both humans and animals (Dobbing, 1968; Winick, 1969), probably the most confident statement we can make in answer to these questions is that adverse effects on mental development in children are most likely to occur, to be rather severe, and long lasting, to the extent that malnutrition begins early in the first year, is severe, and continues for a long period without treatment. When we speak of severe malnutrition at this point, we are talking about infants, for example, whose body weight when hospitalized for treatment at five or six months of age is no greater or even less than birthweight, and who have made little or no gain in

height; or infants whose weight at 10 months is no greater than that of a normal one month old. When we speak of severe effects on intellectual development, we are referring to DQ's or IQ's well below 60, particularly in the Latin-American studies.

Our direct evidence on such matters as the influence of age of onset and duration of malnutrition in children is very limited and unclear, even in the case of severe malnutrition, in part because in retrospective studies it is extremely difficult to get accurate information as to the time when malnutrition began, as well as its duration. Several longitudinal studies being carried on in Mexico (Cravioto, 1969) and Guatemala (Canosa, 1968) should eventually provide us with better data on these issues.

Whether or not the impaired intellectual functioning observed during or after exposure to severe or even moderate malnutrition is subject to remediation is still very much an open question, it seems to me. Our direct evidence on this matter is based almost exclusively on studies in which treatment was aimed primarily at the nutritional and medical needs of the child, as it had to be with severely ill children. In the case of long term follow-up studies, our evidence is based on IQ's which continue to be low in children who for the most part remain in the same social and physical environment which contributed to the development of malnutrition and impaired intellectual functioning in the first place. Would these children continue to function at a reduced intellectual level if it were possible to introduce appropriate environmental changes aimed at fostering learning and psychological development through day care, preschool, elementary school, or home based programs, combined with programs to insure good

health and nutritional status? Until we can begin to answer these and other related questions, we certainly are in no position to conclude that malnutrition produces irreversible adverse effects on children's learning and intellectual development, as some people seem to believe.

Another major problem which still remains unresolved is one that has been referred to frequently during this paper--namely the question of how malnutrition of varying degrees of severity might interact with other associated biological, social and environmental conditions in influencing children's learning and intellectual development (Pollitt, 1969; Pollitt & Ricciuti, 1969; Richardson, 1968). Again, as implied earlier, it's probably reasonable to infer from our research that when post-natal malnutrition is severe, early, and long lasting, its relative influence, in comparison with the other conditions mentioned, is greater than it is when moderate or mild malnutrition is involved in children's development. In the latter case, as I've suggested previously, it's highly probable that moderate or mild malnutrition plays a relatively minor role in determining children's intellectual development and school learning, in comparison with the influence of other social, environmental and genetic factors. Some time ago, a number of us suggested that we might begin to clarify some of these matters by means of experimental intervention studies in which we try to evaluate the influence of various nutritional and educational or experiential interventions, alone and in combination, in facilitating the intellectual development of children with moderate malnutrition (Ricciuti, 1968). Several promising investigations involving some of these approaches are now underway or are being planned by investigators in Guatemala (Canosa, 1968) and Colombia (Latham, 1969).

In the meanwhile, I believe that both as scientists and as practitioners or program planners, we need to be very careful not to be drawn prematurely into inferring from our research the general conclusion that post-natal malnutrition, in and of itself, is a major determinant of severe and permanent impairment of intellectual functioning in children. While many research workers have been stressing the great difficulty of isolating the influence of malnutrition from that of other factors influencing mental development in children, the present climate of heightened concern with the alleviation of malnutrition has helped to produce viewpoints about the relationship between malnutrition, mental development, and mental retardation, that are often over-simplified and sometimes misleading. A recent Editorial (1969) in Science for example, contains the statement: "Children reared in poverty tend to do poorly on tests of intelligence. In part this is due to psychological and cultural factors. To an important extent it is a result of malnutrition early in childhood. /P. 17/". For reasons already indicated, the last part of this statement certainly requires a good bit of qualification. Another example is found in the Medical News section (1968) of a recent medical journal which contains the prominent headline: "Mental Retardation From Malnutrition: 'Irreversible' /P. 30/". The news article then briefly summarizes a report of a very interesting study in Latin America which requires just the kinds of careful interpretation we have been discussing, before one can draw the kind of generalized conclusion so boldy suggested in the headline.

Let me hasten to emphasize here, that the uncertainties in much of our research, which I've been pointing out in some detail, do not carry the slightest suggestion that we should be any less vigorous than we have been in developing programs to eliminate malnutrition and the other unfavorable

educational, economic, and health conditions associated with it. To the extent that we're successful in alleviating these generally adverse conditions wherever they are found, we should not only bring about some improvement in children's nutritional status, but in their potential for learning and intellectual growth as well.

However, there are practical as well as scientific reasons for careful analysis and interpretation of our research findings, and for avoiding premature and overgeneralized conclusions. I believe that in the long run, we're more likely to be successful in developing and maintaining support for sound programs aimed at improving the physical and psychological development of disadvantaged children, if we try to be very clear about the knowledge base and assumptions underlying our plans for such programs, as well as our expectations as to what these programs are likely to accomplish. For example, on the basis of our present knowledge I would say that it would be unwise to initiate large scale food supplementation programs aimed at populations of mild to moderately malnourished children on the principal assumption that improved nutritional status alone would produce a significant improvement in intellectual development and school learning. There are obviously many other important reasons for improving nutritional well-being, but it would be wrong to judge the success or failure of such a program primarily on the basis of inappropriate expectations concerning changes in intellectual functioning.

Similarly, if we consider various school or preschool settings in this country, there are obviously important reasons for schools to be concerned with helping to keep children in good health and nutrition. In many situations, well planned school breakfast or school lunch programs ought to make important contributions to the improvement of the general

well-being of many children. But should these programs be undertaken primarily on the expectation that they will appreciably improve the general level of children's intellectual functioning and school learning through nutritional improvement? Again, I would say "No", although I suspect that premature and overgeneralized conclusions about the relationship between malnutrition and intellectual development might lead some people to regard this as a reasonable expectation for school lunch programs.[4]

It seems to me that our wisest strategy in dealing with issues of this sort is to begin with a careful analysis of the problems and a definition of our specific remediation goals, and then to plan our intervention programs and strategies accordingly. If our main goal in a particular situation for example, is the facilitation of optimal psychological development and school learning in children, then the proportion of our efforts which should go into nutritional remediation, relative to other program efforts, will depend mainly on the severity and scope of malnutrition in that particular situation, and the influence which nutritional improvement is likely to have on children's learning in the context under consideration.

Our capacity to make wise judgements about such matters should be substantially increased, hopefully, as the Pre-School and National Nutrition Surveys begin to provide us with more factual information about the severity and scope of malnutrition in various parts of the United States, and as our continued research efforts begin to provide further clarification of the complicated relationships between malnutrition and

---

4. The possible influence of school lunch or breakfast programs on school performance has apparently been investigated only rarely, with little or no evidence of effectiveness in this regard.

mental development in children. In the meanwhile, it seems to me, as psychologists concerned with the education of children of all ages and backgrounds, we must continue to develop the best possible educational programs to facilitate the psychological development of children in school, day care, and home settings, while remaining sensitive to the important role which malnutrition and other biological factors may play in this process, particularly in the case of children in disadvantaged groups. At the same time, as psychologists and as members of the broader community, we must actively support the development of broad gauged public programs which are aimed at ameliorating the adverse social, economic, and health conditions under which so many of our poor continue to live.

References

Barnes, R. H. Developmental consequences of malnutrition: Experimental studies in animals. Paper read at Conference on Nutrition, Growth, and Development of North American Indian Children, Oklahoma City, May, 1969.

Barrera-Moncada, G. Estudios sobre alteraciones del crecimiento y del desarrollo psicologico del sindrome pluricarencial (kwashiorkor). Caracas: Editora Grafos, 1963.

Beller, K. Effects of anemia on mental functioning in young children. Unpublished manuscript, August, 1969.

Birch, H. G. Health and the education of socially disadvantaged children. Developmental Medicine and Child Neurology, 1968, 10, 580-599.

Birch, H. G., & Belmont, L. Auditory-visual integration in normal and retarded readers. American Journal of Orthopsychiatry, 1964, 34, 852-861.

Birch, H. G., & Lefford, A. Two strategies for studying perception in "brain damaged" children. In H. G. Birch (Ed.), Brain Damage in Children: Biological and social aspects. Baltimore: Williams and Wilkins, 1964, P. 46.

Bliss, D. C. Malnutrition, a school problem. Elementary School Journal, 1921, 21, 515-521.

Brockman, L. M. & Ricciuti, H. N. Severe protein-calorie malnutrition and cognitive development in infancy and early childhood. Unpublished manuscript, 1969. (See also Brockman, L. M. The effects of severe malnutrition on cognitive development in infants. Unpublished doctoral dissertation, Cornell University, 1966.)

Canosa, C. A. Ecological approach to the problems of malnutrition, learning, and behavior. In N. S. Scrimshaw, & J. E. Gordon (Eds.), op. cit., 1968, Pp. 389-397.

Champakam, S., Srikantia, S. G., & Gopalan, C. Kwashiorkor and mental development. American Journal of Clinical Nutrition, 1968, 21, 844-852.

Chase, H. P., & Martin, H. P. Undernutrition and child development. Paper read at Conference on Neuropsychological methods for the assessment of impaired brain functioning in the malnourished child. Palo Alto, June, 1969.

Citizens' Board of Inquiry into Hunger and Malnutrition in the United States. Hunger, U. S. A. Washington, D. C.: New Community Press, 1968.

Cohen, W. J. Statement on hunger and malnutrition in America, before the Sub-Committee on Employment, Manpower, and Poverty, Committee on Labor and Public Welfare, U. S. Senate, June 21, 1968.

Collis, W. R., & Janes, M. Multifactorial causation of malnutrition and retarded growth and development. In N. S. Scrimshaw, & J. E. Gordon (Eds.), op. cit., 1968. Pp. 55-71.

Coursin, D. B. Relationship of nutrition to central nervous system development and function: Overview. Federation Proceedings, 1967, 26, 134-138.

Cravioto, J. Malnutrition and inter-sensory development. Paper read at Conference on Neuropsychological methods for the assessment of impaired brain functioning in the malnourished child. Palo Alto, June, 1969.

Cravioto, J., Delicardie, E. R., & Birch, H. G. Nutrition, growth and neurointegrative development: An experimental and ecologic study. Pediatrics, 1966, 38, 319-372.

Cravioto, J., Gaona, C. E., & Birch, H. G. Early malnutrition and auditory-visual integration in school age children. Journal of Special Education, 1967, 2, 75-82.

Cravioto, J., Pinero, C., Arroyo, M., & Alcade, E. Mental performance of school children who suffered malnutrition in early age. Unpublished manuscript, 1969.

Cravioto, J., & Robles, B. Evolution of adaptive and motor behavior during rehabilitation from kwashiorkor. American Journal of Orthopsychiatry, 1965, 35, 449-464.

Dobbing, J. Effects of experimental undernutrition on development of the nervous system. In N. S. Scrimshaw, & J. E. Gordon (Eds.), op. cit., 1968. Pp. 181-202.

Douglas, J. W. B., & Blomfield, J. M. Environmental influences on physical growth. In Y. Brackbill & G. G. Thompson (Eds.), Behavior in infancy and early childhood. New York: Free Press, 1967. Pp. 525-532.

Drillien, C. M. Growth and development of the prematurely born infant. Edinburgh and London: Livingstone, 1964.

Editorial: Malnutrition, learning, and behavior. Science, 1969, 164, 17.

Egan, M. C. Combating malnutrition through maternal and child health programs. Children, 1969, 16, 67-71.

Geber, M., & Dean, R. F. Psychological changes accompanying kwashiorkor. Courrier, Jan. 1956, 6, 3-15.

Graham, G. G., & Morales, E. Studies in infantile malnutrition I. Nature of the problem in Peru. Journal of Nutrition, 1963, 79, 479-487.

Harlow, M., & Harlow, H. Malnutrition and learning in monkeys. Paper read at Conference on Neuropsychological methods for the assessment of impaired brain functioning in the malnourished child. Palo Alto, June, 1969.

Harrell, R. F. Mental response to added thiamine. Journal of Nutrition, 1946, 31, 283.

Helfer, R. E., & Kempe, C. H. (Eds.) The battered child. Chicago: University of Chicago Press, 1968.

Jelliffe, D. B. Protein-calorie malnutrition in tropical preschool children. Journal of Pediatrics, 1959, 54, 227.

Jelliffe, D. B., & Jelliffe, E. F. P. Field assessment of dietary intake and nutritional status. In N. S. Scrimshaw, & J. E. Gordon (Eds.), op. cit., 1968. Pp. 397-409.

Kay, D. W. K., & Leigh, D. The natural history, treatment, and prognosis of anexoria nervosa based on a study of 38 patients. Journal of Mental Science, 1954, 100, 419.

Klein, R. Malnutrition and behavioral function. Paper read at Conference on Neuropsychological methods for the assessment of impaired brain functioning in the malnourished child. Palo Alto, June, 1969.

Knobloch, H., & Pasamanick, B. Prospective studies on the epidemiology of reproductive casualty: Methods, findings, and some implications. Merrill-Palmer Quarterly, 1966, 12, 45-71.

Kugelmass, I. N., Poull, L. E., & Samuel, E. C. Nutritional improvement of child mentality. American Journal of Medical Science, 1944, 208, 631.

Kuralt, C. Hunger in America. CBS Television Network, May 21, 1968.

Latham, M. C. International nutrition and later learning. In Nutrition and intellectual growth in children. Washington, D. C.: Association for Childhood Education International, 1969. Pp. 33-42.

Leonard, M. F., Rhymes, J. P., & Solnit, A. J. Failure to thrive in infants. American Journal of Diseases in Children, 1966, 111, 600-612.

Lowe, C. U. National nutritional survey of pre-school children. Pediatrics, 1967, 39, 485-487.

Mayer, J. Overweight: Causes, cost and control. Englewood Cliffs, N. J.: Prentice-Hall, 1968.

Medical News Report. Journal of American Medical Association, 1968, 206, No. 1, Pp. 30-31.

Monckeberg, F. Effect of early marasmic malnutrition on subsequent physical and psychological development. In N. S. Scrimshaw, & J. E. Gordon (Eds.), op. cit., 1968. Pp. 269-278.

National Institute of Child Health and Human Development. Nutrition, growth and development of North American Indian Children. (Conference Report) Oklahoma City, May, 1969 (a). In preparation.

National Institute of Child Health and Human Development. Neuropsychological methods for the assessment of impaired brain functioning in the malnourished child. (Conference Report) Palo Alto, June, 1969 (b). In preparation.

Pasamanick, B., & Knobloch, H. Retrospective studies on the epidemiology of reproductive casualty: Old and new. Merrill-Palmer Quarterly, 1966, 12, 7-26.

Pre-school child malnutrition: Primary deterrent to human progress. Washington, D. C.: National Academy of Sciences, National Research Council, 1966.

Pollitt, E. Ecology, malnutrition and mental development. Psychosomatic Medicine, 1969, 31, 193-200.

Pollitt, E., & Granoff, D. Mental and motor development of Peruvian children treated for severe malnutrition. Revista Interamericana de Psicologia, 1967, 1, 93-102.

Pollitt, E., & Ricciuti, H. Biological and social correlates of stature among children living in the slums of Lima, Peru. American Journal of Orthopsychiatry, 1969, 39, 735-747.

Ricciuti, H. N. Panel discussion: Social environment, learning, and behavior. In N. S. Scrimshaw, & J. E. Gordon (Eds.), op. cit., 1968. Pp. 381-384.

Richardson, S. A. The influence of social-environmental and nutritional factors on mental ability. In N. S. Scrimshaw, & J. E. Gordon (Eds.), op. cit., 1968. Pp. 346-361.

Robertson, E. C., Tatham, C. M., Walker, N. F., & Weaver, M. R. The effect of added thiamine on growth, vision, and learning using identical twins. Journal of Nutrition, 1947, 691, 34.

Sandstead, H. H., Carter, J. P., & House, F. R. Nutritional deficiencies in disadvantaged pre-school children and their relationship to mental development. Unpublished manuscript, August, 1969.

Schaefer, A. E. Statement on National Nutrition Survey, before Senate Select Committee on Nutrition and Related Human Needs, U. S. Senate, January 22, 1969.

Scrimshaw, N. S. Malnutrition and the health of children. Journal of the American Dietetic Association, 1963, 42, 203-208.

Scrimshaw, N. S. Ecological factors in nutritional disease. American Journal of Clinical Nutrition, 1964, 14, 112-122.

Scrimshaw, N. S. Malnutrition, learning and behavior. American Journal of Clinical Nutrition, 1967, 20, 493-502.

Scrimshaw, N. S., & Gordon, J. E. (Eds.) Malnutrition, learning and behavior. Cambridge; Massachusetts Institute of Technology Press, 1968.

Smith, A. J., & Field, A. M. A study of the effect of nutrition on mental growth. Journal of Home Economics, 1926, 18, 686-690.

Spitz, R. A. Hospitalism. An inquiry into the genesis of psychiatric conditions of early childhood, I. The psychoanalytic study of the child, Vol. I. New York: International Universities Press, 1945. Pp. 53-74.

Stoch, M., & Smythe, P. M. Undernutrition during infancy, and subsequent brain growth and intellectual development. In N. S. Scrimshaw & J. E. Gordon (Eds.), op. cit., 1968. Pp. 278-288.

Trowell, H. C., Davies, J. N. P., & Dean, R. F. A. Kwashiorkor. London: Edward Arnold Ltd., 1954.

Velez, H., Vasco, J., Echeverri, L., & Vitale, J. J. Effects of a food supplement in addition to free medical care: A study in rural Heliconia, Colombia. Proceedings of Eighth International Congress on Nutrition, Prague, September, 1969.

Winick, M. Malnutrition and brain development. Journal of Pediatrics, 1969, 74, 667-669.